15.—CONTRIBUTIONS TO THE MINERALOGY OF WESTERN AUSTRALIA.

Series IV.

By

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(With Four Text Figures 19, 20, 21, 22).

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(1) APATITE, MT. FRANCISCO, N.W. DIV.

A grey apatite has been found in large coarsely crystalline masses at Mt. Francisco. The colour ranges between Ridgways "slate-grey" and "deep neutral grey." Small imperfect crystals are only occasionally seen penetrating the massive mineral from one of its boundaries. They are a combination of *m* (10—10) and *x* (10—11) with sometimes *s* (11—21) and *c* (0001). Occasional small nests of biotite are enclosed in the masses, and minute scales are visible on fracture faces. Although great care was taken in selecting material for analysis, a little biotite was unavoidably included. The analysis, made by Mr. D. G. Murray, showed:

—	SiO_2	Al_2O_3	FeO	MnO	CaO	MgO	P_2O_5	F	Cl
Per cent. ...	·64	·45	·36	·19	53·74	·58	41·92	2·74	·06
Mols.	11	4	5	2½	958½	14	295	144	2

—	CO_2	H_2O+	H_2O-	Total	$O=F_2$	Net total	Sp. gr.
Per cent.	·06	·46	·04	101·24	1·16	100·08	3·196
Mols.	1	51 (OH)	—	...	...	...	...

The established formula for fluorapatite is $CaF_2.3Ca_3P_2O_8$, or in simpler terms, $Ca_5F(PO_4)_3$. In comparing the results of the above analysis with this it is to be remembered that (OH) is found to displace F in part in a very large number of minerals, and apparently does so in apatite. The calculated ratios from the analysis are:

Ca	F + (OH)	P
4·982	1·015	3·000

with F to (OH) approximately 3 to 1.

It is highly probable that all the recorded cases of "Oxidapatite" (Voelkerite),* in which CaO is supposed to replace part of the CaF_2, are really cases of the substitution of $Ca(OH)_2$ for CaF_2, as in this instance, since it is a common error in analysis to get low figures for both fluorine and hydrogen.

(2) CAESIUM—BERYL, WODGINA, N.W. DIV.

When visiting Wodgina in 1927 the Author found on a dump near the north end of the main tantalite vein (albite pegmatite) several large masses of a white mineral closely resembling quartz, and in fact locally considered to be so. The presence in one specimen of a very faintly discernible cleavage made one hesitate as to its identity, and physical and chemical tests in the laboratory proved that it was beryl.

The mineral occurs in a large pegmatite vein in Archæan greenstone. It is in shapeless masses apparently up to 10 kilos at least in weight, and is not only devoid of external form, but also lacks, except in rare instances, any trace of the usually typical basal cleavage. Its colour in mass is milk-white to water-white, and it is translucent in thicknesses of 0·5 to 1·0 cm. or more. On fracture faces occasional minute flakes of a silvery mica are observable. The chemical composition and physical properties are given below.

A few hundred yards further south on the same vein a single mass of beryl of very different appearance was found embedded in the massive albite. This mineral was streaky grey in colour (light to dark carbon gray) with patches of greenish grey, obviously due to microscopic inclusions, possibly of a chlorite or hornblende. Like the other beryl, it was devoid of crystal faces or cleavage. The results of the physical and chemical examinations are below:

——	SiO_2	BeO	FeO	MnO	MgO.	CaO	Li_2O	Na_2O
White beryl	66·42	11·20	*nil*	*nil*	*nil*	·30	·82	1·01
Grey beryl	60·58	12·00	tr.	0·7	1·18	3·98	·97	1·12

——	K_2O	Cs_2O	H_2O +	CO_2	Al_2O_3	Fe_2O_3	Total.
White beryl ...	tr.	·72	2·20	*nil*	17·97	*nil*	100·64
Grey beryl	tr.	·92	3·00	·02	14·55	1·39	99·78

——	Sp. gr.	O	E
White beryl ...	2·72	1·581	1·575
Grey beryl	2·79	1·588	1·582

* *Vide* Winchell, Elements of Optical Mineralogy, II., 129; Doelter Handb. der Mineralchemie, III. (1), 335.

Both minerals therefore prove to consist of the rare caesium-bearing variety of beryl, sometimes known as rosterite or vorobyevite. The presence of caesium was suggested by the typically pale colour of the chloroplatinate precipitate, and amply confirmed by the spectroscope, which revealed only traces of potassium, but strong evidence of caesium.

Caesium beryl is usually found in lithia-bearing pegmatites and the Wodgina occurrence is no exception to the rule, as the pegmatite which carries the beryl encloses large masses of lepidoite and lithiophilite.

(3) CINNABAR, MARBLE BAR, N.W. DIV.

Whilst preparing a history of mineral discoveries in the State it was found that although some small specimens of cinnabar have been in the possession of the Author for about 15 years, no permanent record has been made of the discovery of this mineral.

The specimens come from the old Just in Time diggings, four miles due South of Marble Bar, and consist of three pieces of the pure mineral weighing respectively 0.4, 0.3 and 0.1 gramme. They are well water-worn and were said to have been obtained when prospecting for alluvial gold. They are between "rosolane purple" and "Schoenfelds purple" (Ridgway) in colour, have a specific gravity of 8·14, and yield mercury when heated with lime in a closed tube.

The geoogical structure of the country at the Just in Time diggings has been described by A. Gibb Maitland.* On the north-east side are the massive and schistose greenstones of the Warrawoona Series (Archaean). On the south-west side these are overlain by the slightly dipping conglomerates, shales, sandstones and lavas of the Nullagine Series (Archaean?). The Warrawoona Series is known to include in many places ultrabasic rocks which are often favourable to the occurrence of mercury.

(4) GLAUCOPHANE, SIDERITE AND CORUNDUM, GREENBUSHES, S.W. DIV.

In 1928 the Government began a series of bores on the Greenbushes tinfield to test the tin-bearing "lodes" (albite pegmatites) below the deepest mine workings, which then only extended to about 150 feet in depth, and included very little driving. A bore on the Dixie M.L. 632 passed through nine different albite pegmatite veins, none of which carried more than traces of tin where they were intersected. Two of these veins were unusual in that they contained appreciable amounts of a bluish-grey mineral which proved to be glaucophane, a mineral previously unknown in Western Australia except for a doubtful occurrence in epidotised dolerite on Synnott Creek, Kim. Div.

Almost throughout the No. 7 vein, extending from 242 to 266 feet below the surface, a deep bluish-grey concentrate was obtained by vanning, followed by concentration with methylene iodide with a density of 2·70. Under

* G.S.W.A., Bull. 40, p. 249-255.

the microscope the bluish mineral was in small, mostly flat, prisms reaching a maximum size of about 0.5 x 0.2 x 0.1 mm. As far as could be determined it appeared that the principal forms present were *m* (110) and *a* (100), with possibly *b* (010). No terminal planes were seen, but a vertical striation was often observable. Crystals lying on *a* or *m* gave biaxial figures with straight extinction. Rarely thin prisms, apparently lying on *b*, gave an extinction angle ranging from 4° to 6°. The specific gravity (by CH_2I_2) was 3·15 ± ·03. Optical tests showed that Z and X lay in the plane (010), with Z making an angle of 4° to 6° with the vertical axis. Pleochroism was very marked, with maximum absorption approximately parallel to the elongation, the common scheme being: Z deep cobalt blue; Y purplish blue; X colourless to very light amber. Ng was found to be 1·640; Nm 1·637; Np 1·624; all ± ·003. A few pleochroic haloes were observed round minute inclusions, and an occasional small zircon was recognisable embedded in a crystal. The macroscopic appearance of the mineral in this vein is unknown, as it was first recognised in the concentrates from the crushed rock. The characters determined on the powder leave no doubt, however, as to its identity.

After the detection of glaucophane in the No. 7 vein a close examination was made of the remaining cores before crushing. In certain portions of No. 8 vein extending from 273 to 291 feet in the bore glaucophane was again encountered. For a few inches near the upper margin of the vein, radial aggregates of minute lavender-blue prisms were quite common, the masses reaching a maximum of one centimetre in diameter. They were embedded in a mixture of granular albite, quartz and biotite, with small amounts of garnet and other minerals. A crushed concentrate of the lavender mineral presented all the significant characteristics of that from the No. 7 vein, but the crystals were more acicular, and some showed a parting at right angles to the elongation on one face (*a*?) but making an angle of 64° to 66° with the elongation on another (*b*).

The minerals accompanying glaucophane in the No. 7 vein were of more than passing interest. Throughout the 24 ft. of core granular albite and quartz were the most abundant minerals. Amongst the minor minerals schorl, ilmenite, garnet and apatite were the most common, with traces of cassiterite, zircon, sphene, biotite, pyrite and rutile. Glaucophane was detected in the upper 14 ft. of core, and was most abundant in the first 6 feet. The concentrate from the first four feet carried about 70 per cent. of siderite in dull yellow to brown granular masses. This is the first time the Author has seen or heard of this mineral in a pegmatite. Apatite was common throughout, occurring in stout prisms about 0·2 mm. in length, presenting characteristic optical properties and readily soluble in cold dilute nitric acid. Finally the concentrate from the middle three feet of the vein included some small corundum crystals. Similar crystals were more plentiful in a similar vein at 215 ft. in the No. 4 bore on the adjacent Cornwall M.L. There they formed imperfectly developed prisms and bipyramids about 0·2 x 0·06 mm. in size. The presence of small rhombohedral truncations, the corroded surface, straight extinction, high refringence, low birefringence with negative elongation, and the slight pleochroism (O, lilac; E, colourless) serve to identify the species.

(4) ILMENITE, WOODSTOCK, N.W. DIV., AND WANNAMAL, S.W. DIV.

MANGANILMENITE, Woodstock. A few miles south-east of Cunmagnunna Trig. (B4) on Woodstock Station (Lat. 21° 48′ S., Long. 115° 55′ E.) and not far from the place where the tanteuxenite previously described was found,* a number of angular pebbles were picked up on the surface, which proved to be composed of a very unusual variety of ilmenite. The country for some distance round consists of Archaean granite traversed by pegmatite veins, one of which was probably the original matrix of the mineral.

The pebbles varied from one to several centimetres in diameter and showed no signs of crystallisation beyond a single imperfect cleavage in most fragments and a small development of *c* (0001) and *s* (02-21) on one. They were brownish black within, but much weathered on the surface, which had a coating of light brown decomposition products.

One of the freshest looking fragments was freed from the latter as far as possible by chipping, immersed for a few moments in HCl and HF, and then well washed and dried. The analytical results obtained were:

——	Fe_2O_3	FeO	MnO	MgO	CaO	TiO_2	SiO_2	H_2O	Total
Per cent.	12·12	21·27	14·40	trace	*Nil*	51·79	·80	trace	100·38
Mols. ...	76	296	203	...	...	647	13	...	...

The specific gravity was 4·63.

If the whole of the Fe_2O_3 be considered as due to oxidation of primary FeO, the original ratio of FeO+MnO: TiO_2 becomes 651: 647, practically one to one, corresponding to the generally accepted formula for ilmenite. The mineral from Woodstock, however, differs from normal ilmenite in the large proportion of the pyrophanite molecule ($MnTiO_3$) which is present. The only other analysis similar to it in this respect is one of a mineral from Rocroi, France, quoted by Doelter,† which shows 15.15 per cent. of MnO. Of this Doelter says: "it deserves to be provided with a distinct name."

For this manganiferous variety of ilmenite the name "manganilmenite" is suggested.

MENACCANITE, Wannamal. The molecules $FeTiO_3$ and Fe_2O_3 are completely isomorphous, and most ilmenites contain appreciable amounts of Fe_2O_3 even when quite fresh. A large number of unnecessary names have

* J.R.S.W.A. xiv. 46.

† HB. der Min. Chem. III. (1) 48.

been given to varieties of ilmenite differing only in the various proportions of the haematite molecule, but the old-established name menaccanite might well be retained for those with approximately equal molecules of $FeTiO_3$ and Fe_2O_3, say with 40 to 60 per cent. by weight of Fe_2O_3.

The only comparatively large deposit of ilmenite in the State belongs to this variety. It occurs in a low range of hills just east of the railway, between Wannamal and Mogumber, in Lat. 31° 10′, Long. 116° 5′. This range is composed of gneissic granite traversed by occasional dykes of greenstone. The actual outcrop of the menaccanite, except in one spot on Loc. 1589, is obscured by soil, but surface boulders were traced in a northerly line for about a mile, and, according to a local resident, continue for a further half-mile in each direction. Accompanying the loose surface boulders of menaccanite are boulders of epidiorite at frequent intervals, and the indications are that the titanium mineral is not in a continuous lode but exists as a series of large segregations in the epidiorite. On Loc. 1589 there is an outcrop of solid granular menaccanite standing as much as three feet out of the soil and covering an area of 10 to 15 square yards. An average sample from this, which included visible specks of kaolinised felspar, had the following composition:—

——	Fe_2O_3	FeO	MnO,MgO	CaO	TiO_2	SiO_2	Al_2O_3	H_2O	Total
Per cent.	49·93	19·76	traces	*nil*	22·79	1·35	5·28	·60	99·71
Mols. ...	313	275	...	...	284	22	52	33	...

Previous samples collected along the same line of outcrops had yielded 21·60 and 26·30 per cent. of TiO_2. The character throughout is similar, rather finely granular black masses with minute inclusions of kaolinised felspar.

(6) MANGANOCOLUMBITE, TABBA AND MT. FRANCISCO, N.W. DIV., AND GIBRALTAR, CEN. DIV.

TABBA. The occurrence of manganocolumbite in association with manganotantalite at Tabba was referred to in the Annual Report of the Chemical Branch for 1927 (p. 17). Selected pebbles from detrital concentrates are mostly somewhat tabular, often showing the faces (100), (010) and (001) with occasionally (133). See Fig. 19. They are pure black to dark brown on the weathered surface, pure black on a fresh fracture, which is uneven, with a submetallic lustre. The specific gravity ranges from

6.15 to 6.28 in one parcel, and from 6.06 to 6.50 in another. Two pebbles from M.L. 317 with gravity varying from 6·22 to 6·25, and weighing in all somewhat less than six grammes, were analysed with the following results:—

—	Ta_2O_5	Nb_2O_5	TiO_2	SnO_2	FeO	MnO	CaO	MgO
Per cent.	48·00	32·74	·91	·42	6·21	9·96	·08	·08
Mols. ...	108	123	11	3	86½	140½	1½	2

—	Fe_2O_3	Al_2O_3	H_2O	Total	Sp. gr.
Per cent.	·11	·23	·72	99·46	6·24
Mols.	...	2	40	...	...

The ratio of M_2O_5 : MO in this analysis is 462 : 461, the figures being due to Mr. H. P. Rowledge.

The fine powder of the mineral is almost pure black in colour, and under the microscope is completely opaque. These details are recorded, as some other manganese tantalo-niobates now under examination are much paler in colour, and are transparent under the microscope.

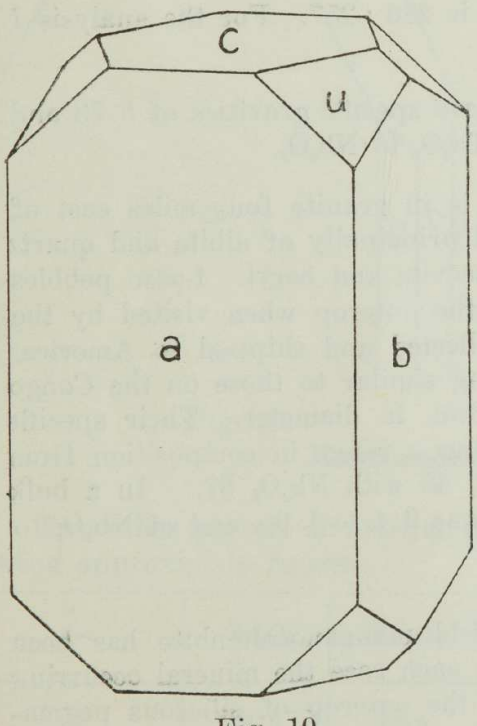

Fig. 19.
Manganocolumbite,
Tabba.

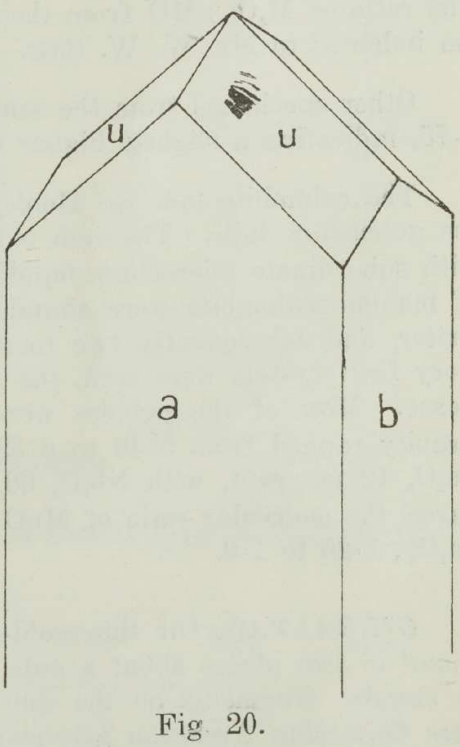

Fig 20.
Manganocolumbite,
Mt. Francisco.

MT. FRANCISCO. The existence of manganocolumbite in considerable quantities at this place has been known for many years, but attention has been again drawn to it by the recent sale of two tons of detrital ore from Hooley's lease.

The first find of the mineral was on the Congo Lease in pegmatite in the greenstone hills. Here masses up to a kilo in weight are to be seen embedded in albite and quartz. Good single-ended crystals have been collected, growing in parallel position from the sides of a narrow fissure filled by the crystals and secondary albite. The forms present in each case are (100), (010) and (133). See Fig. 20. On a fresh fracture the mineral is greyish black, the lustre being submetallic, and fracture uneven. The fine powder is brownish black, and under the microscope quite opaque.

A typical specimen had the following composition:—

—	Ta_2O_5	Nb_2O_5	TiO_2	SnO_2	SiO_2	FeO	MnO
Per cent.	31·07	47·90	1·62	·40	·28	2·66	14·88
Mols.	70	180	20	3	5	37	210

—	CaO	MgO	Fe_2O_3	Al_2O_3	H_2O	Total	Sp. gr.
Per cent.	·34	·16	trace	·35	·42	100·08	5·87
Mols.	6	4	...	3	23	...	...

The ratio of M_2O_5 : MO from these figures is 250 : 257. For the analysis I am indebted to Mr. W. W. Saw.

Other specimens from the same lease have specific gravities of 5·73 and 5·75, indicating a slightly higher ratio of Ta_2O_5 to Nb_2O_5.

The columbite lode on Hooley's lease is in granite four miles east of the greenstone hills. The vein is composed principally of albite and quartz with subordinate microcline, lepidolite, muscovite and beryl. Loose pebbles of manganocolumbite were abundant near the outcrop when visited by the writer, and subsequently two tons were collected and shipped to America. Very few crystals were seen, the form being similar to those on the Congo Lease. Most of the pebbles were about 3cm. in diameter. Their specific gravity ranged from 5·46 to 6·32, indicating a range in composition from Ta_2O_5 12 per cent. with Nb_2O_5 68, to Ta_2O_5 45 with Nb_2O_5 37. In a bulk parcel the molecular ratio of MnO to FeO was 2·4 to 1·0; and of Nb_2O_5 to Ta_2O_5, 1·25 to 1·0.

GIBRALTAR. On this gold-mining field manganocolumbite has been found in two places about a mile apart, in each case the mineral occurring in angular fragments on the surface near the outcrop of siliceous pegmatites traversing Archaean greenstones.

On the Lloyd George gold-mining lease only a few small broken crystals have been collected, the faces *a* (100), *b* (010), *c* (001), *m* (110), *e* (021) and *u* (133) being represented. The specific gravity varies from 5·48 to 6·00, indicating a percentage of Ta_2O_5 varying from about 13 to 33, and the predominating base is manganese. This mineral has an uneven fracture, rather dull and black in colour. The powder is quite opaque.

On the Bendigo lease the mineral is much more plentiful. It resembles that described above in lustre, fracture and diaphaneity. An analysis of a typical specimen gave the following results:—

—	Ta_2O_5	Nb_2O_5	TiO_2	SnO_2	SiO_2	FeO	MnO
Per cent.	27·28	51·17	1·75	·12	·39	7·87	10·16
Mols.	62	192	22	1	6	110	143

—	CaO	MgO	Fe_2O_3	H_2O	Total	Sp. gr.
Per cent.	*nil*	*nil*	1·70	·14	100·58	5·81
Mols.	...	...	11	8	...	...

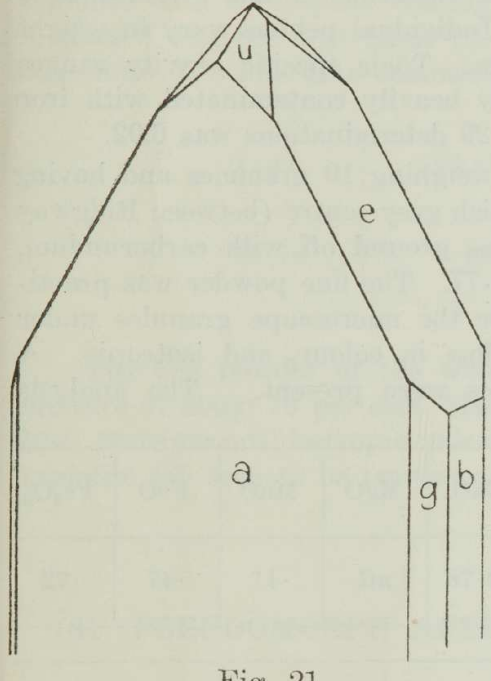

Fig. 21.

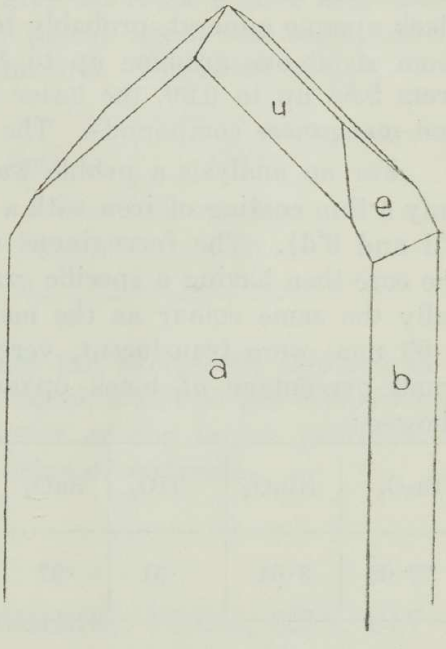

Fig. 22.

Manganocolumbite, Gibraltar.

Two other parcels of detrital pebbles of a similar type yielded the following approximate figures:—

—	Ta_2O_5	Nb_2O_5	TiO_2, etc.	FeO	MnO	Sp. gr.
A	16·2	62·9	1·4	9·7	9·8	5·57
B	20·8	57·0	3·5	9·3	9·4	5·68

The specific gravities determined on a number of specimens from the Bendigo lease ranged from 5·54 to 6·49, indicating a percentage of Ta_2O_5 varying from about 14 to 52. The crystalline forms observed were *a* (100), *b* (010), *c* (001), *m* (110), *y* (210), *g* (130), *e* (021), *u* (133). Two typical crystals are shown in Figs. 21 and 22.

(7) MICROLITE, WODGINA AND GREEN'S WELL, N.W. DIV.

Previous references have been made to the existence of microlite in the Wodgina district,* probably at Greens Well. Specimens received through reliable persons during 1928 leave no doubt but that microlite occurs in small quantities both at Wodgina itself and in the McPhees Range near Greens Well, 23 miles E.N.E. of Wodgina.

WODGINA. The mineral has only been detected so far in alluvial pebbles in a stream bed less than a mile north of the Tantalite Mine (M.L. 86). The surface of most of the pebbles is remarkably like that of meteoric stones, there being a thin coating of brownish black lateritic iron ore, and the form being "thumb marked" with rounded depressions. On a fresh fracture the pebbles below the thin crust are opaque and light to dark grey, sometimes greyish pink in colour. Examination of the fine powder under the microscope discloses that the major portion, which is microlite, is colourless to pale yellow in colour, transparent and isotropic. With it, and accounting for the grey colour in mass, are numerous minute granules of a black opaque mineral, probably tantalite. Individual pebbles vary in weight from about one gramme up to 40 grammes. Their specific gravity ranges from 5.54 up to 6.90, the latter apparently heavily contaminated with iron and manganese compounds. The mean of 29 determinations was 6.02.

For an analysis a pebble was chosen weighing 10 grammes and having only a thin coating of iron with a pale pinkish grey centre (between Ridgway 9'd and 9'd). The ferruginous coating was ground off with carborundum, the core then having a specific gravity of 5·77. The fine powder was practically the same colour as the mass. Under the microscope granules under 0·03 mm. were translucent, very pale yellow in colour, and isotropic. A small percentage of black opaque granules were present. The analysis showed:

Ta_2O_5	Nb_2O_5	TiO_2	SnO_2	SiO_2	CaO	MgO	MnO	FeO	Fe_2O_3
77·00	3·64	·51	·37	·40	12·78	*nil*	·11	·47	·72

Al_2O_3	Na_2O	K_2O	F	H_2O +	Total	Less O = F_2	Net total.
·55	1·18	·15	1·09	2·00	100·97	·46	100·51

There was no trace of Ce_2O_3, Y_2O_3, Sb_2O_5 or UO_3 to be detected in it.

The molecular ratios calculated from the above figures are:

$(Ta, Nb)_2O_5$	$(Ti,Sn)O_2$	(Ca,Fe)O	(Na,K)	F	H_2O
188	8	236	41	57	111

If the formula for microlite be $CaTa_2O_6.NaF$, these figures indicate a weathering of the mineral, the most marked effect being a removal of two-thirds of the sodium and fluorine, a slight concentration of the lime, and an assumption of water.

GREENS WELL. A few alluvial pebbles containing microlite have been obtained in McPhees Range near Greens Well. They resemble the Strelley specimens previously described.* With them is a crystal of pure tapiolite weighing 18 grammes and showing the forms (100), (001), (110), (111), the crystal being elongated parallel to the edge p^1 p^2, and having a specific gravity of 7·52.

Two large, but very imperfect crystals, resembled the Strelley specimens in having portions of the surface converted into opaque, greyish-yellow microlite. In consequence the bulk specific gravity is reduced to 6·95 and 6·85.

Several uncrystallised pebbles show much greater replacement of tapiolite by microlite: in one case, which is almost complete, the specific gravity is 6·01. In others it is 6·61, 6·64, etc., the approximate gravity of pure microlite being 5·70. One specimen exhibits on fracture a core of black tapiolite with a complete coating of light grey microlite 2 to 4 mm. thick. A partial analysis was made of the mixed parcel which was submitted to determine its value as a commercial tantalum ore. The result was:

Ta_2O_5	Nb_2O_5	SnO_2	CaO
75·76	6·92	·14	5·50

The fine powder of the whole ore under the microscope appears as a mixture of about 70 per cent. black opaque tapiolite and 30 per cent. colourless, transparent, isotropic microlite. Several of the larger particles of tapiolite are seen to be traversed by small veins of microlite.

(8) PSEUDOMORPH AFTER SPODUMENE, UBINI, CEN. DIV.

The amblygonite-bearing pegmatite vein in Archæan greenstones at Ubini was examined last year for other uncommon minerals. The chief constituents of the vein appear to be quartz, albite and microcline, with bunches of lepidolite, muscovite, and amblygonite in places, and rare specimens of cassiterite and manganotantalite.

A near-by vein which has been opened up for pottery felspar consists mainly of albite and microcline, with some lepidolite. From this vein a few specimens were collected, which appear to be felspathic replacements of spodumene (a mineral not yet detected at Ubini) similar to the "cymatolite" of Massachusetts and Connecticut.† The material is in dull white, slightly porous masses, with a subfibrous structure at right angles to the broadest face. The masses reach 12 x 10 x 8 cm. in size and are closely associated with perfectly unweathered and coarsely crystallised albite and lepidolite.

* Jour. R.S.W.A., xiv., 48-49.

† Dana. Sys. of Min. VII., 368.

An analysis was made of a characteristic fragment which had an apparent specific gravity in CH_2I_2 of 2·59:

SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	K_2O	Na_2O	Li_2O	H_2O+	H_2O-	Total
69·64	18·28	trace	·28	*nil*	4·87	6·36	trace	·63	·33	100·39

This corresponds approximately to an intimate mixture of:

Albite.	Microcline.	Muscovite.	Quartz.	Talc.?
53·8	21·7	10·1	13·5	·09

(9) SPINEL, GIBRALTAR, CEN. DIV., AND PEMBERTON, S.W. DIV.

Spinel has not, up to the present, proved to be a common mineral in Western Australia, though its natural matrices, olivine and serpentine rocks, are widespread. The only records of its occurrence are as large segregations in basic rocks at Mt. Francisco * and Miling,† and as occasional grains in heavy black sands at several points in the far South-West.

GIBRALTAR. An unusually black and fine-grained rock collected in an open cut on the Lloyd George Mine was found on sectioning to be a very fresh peridotite. The chief constituent was granular olivine, much cracked, but with only very thin films of serpentine along the cracks. Minor constituents were a white mica, magnetite and pyrite. The most striking constituent of the rock, however, was a transparent green (Ridgway 31″k) spinel, which was very abundant in dense groups and strings of granules, 0·02 to 0·20 mm. in diameter.

PEMBERTON. As an example of the South-West occurrences may be taken that at Pemberton. Three sands collected from creeks between Pemberton and Fly Brook, and partly concentrated, were composed of the following minerals in descending order of frequency:—

A. Quartz, garnet, rutile, ilmenite, kyanite, spinel, zircon.

B. Quartz, felspar, ilmenite, zircon, rutile, kyanite, spinel, staurolite, garnet.

C. Quartz, ilmenite, zircon, kyanite, spinel, staurolite, garnet, tourmaline.

In each case the spinel is in grains of 0·5 to 4 mm. diameter, light bottle-green to greenish black in colour, transparent to opaque in thicknesses of 1 mm., and isotropic. The specific gravity was found to be 3·61. Some grains have recognisable octahedron faces. The original matrix of the mineral is unknown.

* An. Rept. Chem. Branch W.A., 1923, p. 11 ; Amer. Mineralogist 13, p. 461.

† Mineral Mag. 19, p. 99-106.

(10) TOURMALINE, WODGINA, N.W. DIV.; GREENBUSHES, S.W. DIV.; AND KALGOORLIE, CEN. DIV.

SCHORL (Indicolite), Wodgina. On a dump on the Mt. Cassiterite Tin Mine (M.L. 84) large masses of deep blue tourmaline are plentiful, apparently derived from the biotite-chlorite schist forming the wall of a pegmatite vein. Structurally the masses consist of a compact felt of minute prisms, a fresh fracture showing some portions to be much finer grained than others. The finer portions are coloured "dusky blue" (Ridgway 49* m), the coarser "indulin blue" (51*m). Under the microscope the largest prisms measure about 2 x 0·2 mm, the average being about one quarter that size. O is cornflower blue, E colourless.

An analysis by Mr. D. G. Murray proves that the mineral belongs to the species "schorl," $H_5NaFe_4Al_8B_4Si_8O_{41}$. See table below.

DRAVITE and SCHORL, Greenbushes. A black tourmaline is especially abundant throughout this tin field, most of it forming part of, or being derived from, the tin-bearing pegmatites, those on the Cornwall Lease carrying large proportions of the mineral, and one on the Lost and Found Lease being composed of almost equal parts of tourmaline and albite. A single alluvial boulder of it was found many years ago in Floyds Gully which weighed 40 kilos (90 lbs.). This was composed of a dense mass of coarse prisms, ranging up to 1 cm. in diameter, and of an almost pure black colour (Ridgway's dark or dusky neutral grey). Under the microscope the colours were O, very dark grey blue; E, pale smoke brown.

An analysis made by Mr. H. P. Rowledge of this large boulder shows that the species present is a ferruginous "dravite," $H_5Na(Mg,Fe)_4Al_8B_4Si_8O_{41}$, the atoms of Mg being nearly twice as numerous as those of Fe″. The figures are given below.

The black tourmaline occurring plentifully in masses up to a centimetre in diameter in a pegmatite vein at 268 ft. on the Cornwall lease was partly analysed to determine its species. Although in outward and microscopic appearance (including pleochroism) it is similar to the large alluvial boulder, the analysis showed the presence of 14·86 per cent. of FeO, when the whole of the iron was calculated to that form, with only 0·51 per cent. of MgO. This mineral therefore is a typical schorl. Its specific gravity is 3.15, slightly greater than the more magnesian mineral.

DRAVITE, Kalgoorlie. An undetermined species of tourmaline is widespread in sporadic small, usually microscopic, prisms in both rocks and lodes at Kalgoorlie. In addition, in a quartz vein in Archaean greenstone at Mt. Hunt is a tourmaline of most unusual appearance. In colour it varies from Ridgway's "pale neutral grey" to "deep neutral grey." In structure it is in very finely fibrous, almost silky masses, up to 15 cm. in length, and from 1 to 10 cm. in width and thickness. At first sight it is not unlike some "mountain wood." A thin slice exhibits a dense mass of practically parallel fibres ranging from 0·02 to 0·04 mm. in diameter and reaching to a centimetre or possibly more in length. They cannot be followed indefinitely in length owing to their slight curvature. In section E is colourless, and O mostly light greyish-green, but also in small part light smoke-brown.

The composition, given below, is that of a ferruginous dravite, not unlike that from Greenbushes, the ratio of MgO to FeO being 2·4 to 1·0.

	Indicolite (Schorl), Wodgina.	Ferruginous Dravite, Greenbushes.	Fibrous Dravite, Kalgoorlie.
SiO_2	36·06	36·02	36·78
TiO_2	*nil*	·58	·40
H_2O + ...	1·98	3·82	3·68
Li_2O	·26	·10	trace
Na_2O	1·76	1·48	2·35
K_2O	trace	·08	·05
MgO	·27	7·81	8·75
CaO	·37	·80	·76
MnO	·35	·21	·20
FeO	10·68	7·17	6·54
Fe_2O_3	1·99	·38	trace
Al_2O_3	35·97	31·45	30·83
Cr_2O_3	*nil*	·05	*nil*
B_2O_3	10·48	10·33	10·06
F	·87	·22	·08
H_2O—	*nil*	·10	*nil*
Total	101·04	100·60	100·48
Less O = F_2 ...	·37	·09	·03
Net total	100·67	100·51	100·45
Sp. gr.	3·15	3·12	3·09
Analysts	D. G. Murray	H. P. Rowledge	E. S. Simpson

(11) VESUVIANITE, TAMBOURAH, N.W. DIV.

The first discovery of vesuvianite in the State has been made near Tambina Creek, six miles north of Tambourah, in Lat. 21° 40′ S., Long. 119° 10′ E. The mineral is in coarsely crystallised groups with brilliant prism faces of a brownish-black colour. Internally the colour is somewhat lighter, inclining towards an olive brown. The largest prism seen is 4 cm. square, both ends being missing. The broad *m* (110) faces are strongly striated by multiple repetition of vicinal faces, and some show a tendency to scale off. The *a* (100) faces are rather narrow, and are accompanied by bevels of *h* (310) and *f* (210). In several crystals the basal plane is intact. A basal section of a small crystal gave a good uniaxial figure, and showed a zonal structure, with the centre light pinkish-brown, the narrow border darker brown. A vertical section showed a very slight pleochroism, X (c) very pale green or brown, Z darker brown.

There are two well-recognised varieties of vesuvianite. The normal one contains no boron, or only traces; in "viluite," B_2O_3 substitutes Al_2O_3 to the extent of 2 or 3 per cent. As fluorine has been detected in all vesuvianite in

which it has been looked for, and lithium in several, the Tambourah mineral was carefully tested for boron, fluorine and lithium. The results of the analyses made for me by Mr. D. G. Murray were:

SiO_2	B_2O_3	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O
36·75	*nil*	16·51	2·73	3·00	·33	1·55	35·28	·12	·10

Li_2O	H_2O+	TiO_2	F	Total	$O = F_2$	Net total.	Sp. gr.
·06	1·25	2·17	1·80	101·65	·76	100·89	3·42

The formula calculated from the analysis is $Ca_{12}Al_6Si_{10}(OH,F)_4O_{30}$; the molecular ratios being as follow. Against them are tabulated the ratios accepted by various authorities:—

——	Tambourah.	Dana.	Hintze.	Winchell.
SiO_2	10·58	10	35	8
M_2O_3	2·96	3	10	2
MO	11·80	12	40	8
(OH, F)	3·89	4	14	4

The only associated minerals observed were quartz and travertine. No information is available regarding the mode of occurrence at Tambourah, but the district is known to be occupied by Archaean granite and greenstone.

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